〈**Transportation**〉

Service Sector AGV

Service sector, AGV, Autonomous moving robot, Image processing, Laser range finder

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Abstract

In response to a decrease in labor force and an increase in workloads by low birthrate and aging population, the development of service robots became active in the industry. Based on technologies of the Automated Guided Vehicle (AGV) that carries cargoes instead of actual people, we have developed a service sector AGV for service fields that carries items while following service personnel and avoiding obstacles. The AGV is a guided cart that follows a guided path, however, the service AGV does not require any preset guide path. It utilizes image recognition of a special mark previously programmed and follows service personnel who wear this mark. Using a laser range finder, it detects the presence of obstacles near the AGV. Therefore, the service sector AGV can automatically follow the motion of service personnel and can avoid obstacles.

1. Preface

The Automated Guided Vehicle (AGV) is an automated guided cart that follows a guided path. This equipment is widely used in industrial fields and places of physical distribution. We have developed a new type of AGV that has additional functions such as following the motion of people and avoiding obstacles on the course it is traveling on. Therefore, it can work with service personnel even though there is no pre-determined guided path (see Fig. 1).

A condition of this AGV design is that it works together with service personnel and it can be applied in service fields (service sector AGV). This paper introduces the features of the service sector AGV and its applicable fields.

Fig. 1 Service Sector AGV
This shows the external appearance of service sector AGV.

2. Features

The service sector AGV functions are to follow the motion of service personnel and avoid obstacles. Fig. 2 shows the functional block diagram. The sensor block is composed of a camera, laser range finder and its operator, and the track planning unit.

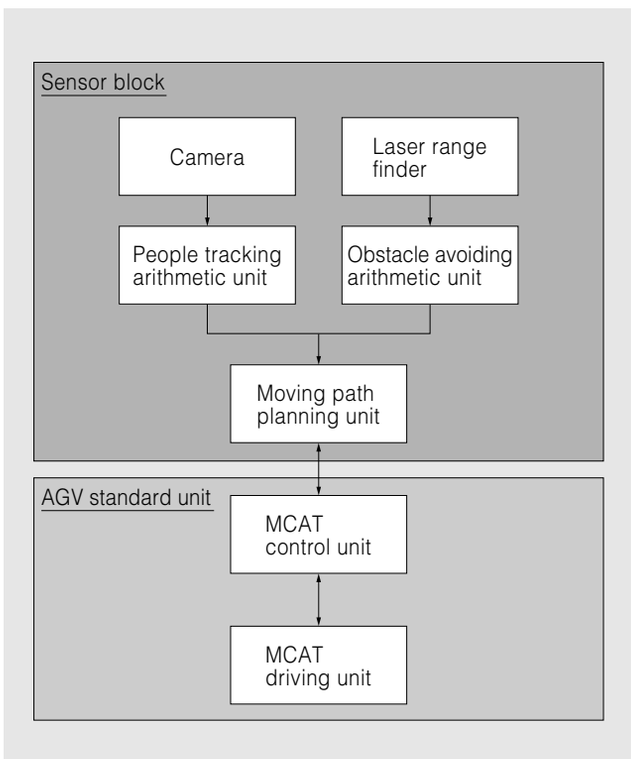

Fig. 2 Functional Block Diagram
Thanks to the service personnel tracking function and the obstacle avoiding function, the service sector AGV can track the service personnel while avoiding the obstacles along the moving path.

2.1 Tracking Functions

By using image recognition, this AGV identifies a mark that is attached to the target on service personnel and can travel in the direction that mark indicates. For mark recognition, it employs image feature section technologies. An image that matches the pre-registered mark is extracted from multiple camera images. The distance and direction to this mark are constantly computed and this AGV can continuously follow the person with the mark.

Assigning and modifying the mark can be done easily. By programming a different mark to each service sector AGV, we can operate multiple AGV units.

2.2 Obstacle Avoidance Functions

Since the AGV is equipped with a laser range finder, it is possible to locate obstacles that exist around the service sector AGV. As shown in Fig. 3, for example, the obstacle position is located with the use of the laser range finder as shown in Fig. 4 if partitions are put around the service sector AGV. To avoid collision with the detected obstacle, the traveling direction is determined to avoid collision with the obstacle. In case of Fig. 3, the mark is positioned in a higher level than the partition height. Therefore, the camera can take in an overall image.

Since the traveling speed is determined according to the distance to the obstacle. When the AGV goes through a narrow pathway, it slows down and travels safely.

2.3 Track Planning Function

To track service personnel while avoiding the obstacles, the traveling direction is selected by considering both the mark-moving direction and the obstacle-free direction. If there is any obstacle between the service sector AGV and the mark, the AGV is able to move toward the service personnel while avoiding the obstacle. Moving direction is continually computed and can accurately plan ahead to follow the tracking course of the service personnel so that the track (course) can be determined to follow up the service personnel assuredly.

According to an example shown in Fig. 3, the tracking course was selected in the direction where no obstacle was found because there was an obstacle identified in the direction of the mark as shown in Fig. 5.

Since the service sector AGV can determine a path to follow the motion of service personnel while avoiding any obstacle along the way, the steady tracking of the service personnel occurs.

2.4 Reverse Functions

The service sector AGV can move in synch within a proper preset distance while following service personnel. Therefore, if the target service personnel approaches the service sector AGV, this AGV will move backwards

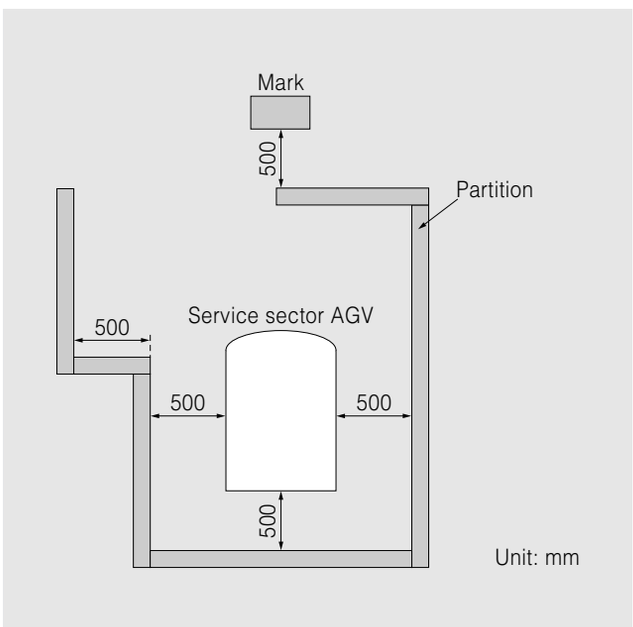

Fig. 3 Example of Moving Path

We put partitions along the moving path of service sector AGV. In this case, we explain the moving path to keep track of the mark.

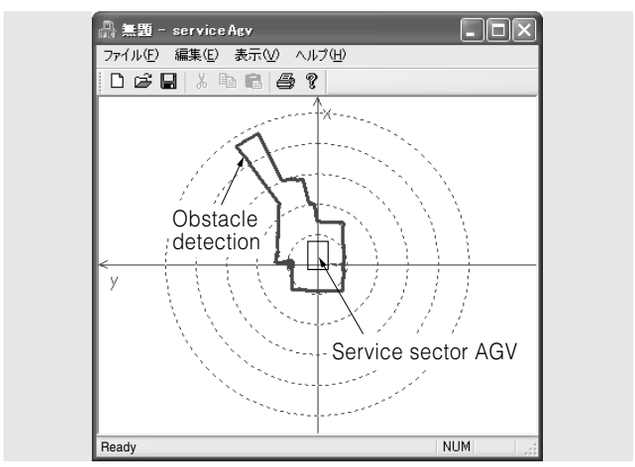

Fig. 4 Obstacle Detection by Laser Range Finder

The laser range finder is used to detect the location of an obstacle existing around the service sector AGV.

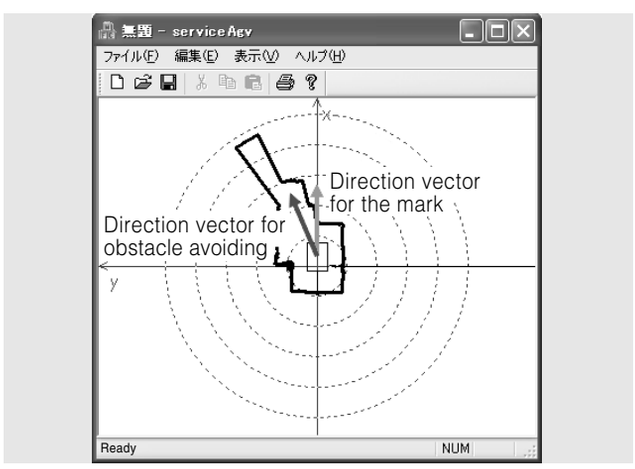

Fig. 5 Pattern Diagram on Moving Direction Decision

This shows moving in a direction to keep track of the mark while averting an obstacle.

to maintain a certain pre-set distance. This distance is changeable. According to the type of work required, the tracking distance can be easily changed.

If there is an obstacle in the path towards service personnel and the AGV is not able to follow the individuals, this service Sector AGV has a function to temporality move backwards and seek any other safe moving direction option. With such a feature, it could continue a steady tracking towards the service personnel.

2.5 Design

Unlike conventional AGVs, the newly developed service sector AGV is intended to work together with service personnel. It is, therefore, not simply considered just "transport equipment," but the design concept is a robot working very closely with the service personnel. Fig. 6 shows the design sketch. The key design points at the designing stage are listed below:

(1) Curvy shape, appealing design to people

(2) Soft and bright color without inducing any undue mental stress

Fig. 6 Design Sketch of Service Sector AGVs

For the purpose of working together with service personnel, we designed it with the curvy shape and without giving an over-bearing feeling.

Fig. 7 AGV Controller

This shows an external appearance of the AGV controller.

(3) No overbearing design; its simple shape gives the sense of potentialities and spirit of innovation by a design that considers the nature of collaborative work.

(4) An LED indicator is located on front of the AGV unit to illuminate the AGV and to let the people working around the AGV know it's operating status.

These design features helped to ensure safety and peace of mind.

2.6 AGV Functions

To develop conventional AGV functions, we use our MCAT units for the AGV controller (see Fig. 7) and the drive unit (see Fig. 8). Therefore, the service sector AGV can work as a conventional guided-track following AGV. Table 1 shows MCAT specifications.

The model can be easily changed between the tracking model and ordinary guided-path traveling mode by using the mode change switch.

3. Application Fields

The service sector AGV can be applied to various fields. For example, the following applications are considered possible:

(1) Shipping storage warehouses

The service sector AGV can carry items picked up by the service personnel and can keep track of such individuals. After the work is picked up, it acts as an ordinary guided-path-following AGV and automatically travels to the shipping yard. Fig. 9 shows an image of

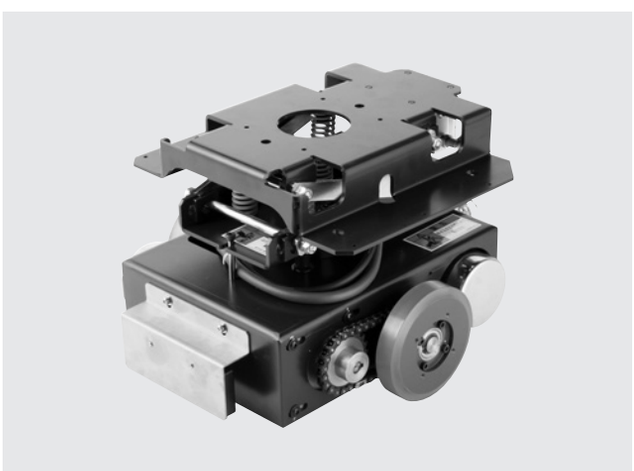

Fig. 8 Drive Unit

This shows an external appearance of the drive unit.

Table 1 MCAT Specifications

This shows the major specifications of light-weight class and high-speed type MCAT.

Item	Specifications
Guiding system	Magnetic guide path
Max. speed	60m/min
Permissible loading (total mass)	250kg
Road slope level	2%
Stop accuracy	±15mm
Power source	24V battery unit

Fig. 9 Image of Work Being Picked Up
In a shipping strong warehouse, the service sector AGV carries items picked up by service personnel and can keep track of individuals.

Fig. 10 Image of Service in a Medical Facility
In a hospital, the AGV serves a meal while following a doctor and a nurse from behind.

the work being picked up.

(2) Application to medical and welfare fields

This AGV is considered to be used as a meal serving cart in the medical and welfare facilities. It may also be used as a cart carrying stretchers, medicines, and clinical record cards instead of having someone transport such items. Fig. 10 shows an image of service in a medical facility.

The service sector AGV can work together with service personnel doing the material transport work.

Table 2 Service Sector AGV Specifications
This shows major service sector AGV specifications.

Item	Specifications
Guiding system	Modal switching between mark tracking mode by image sensor and the guided path moving mode on magnetic path
Max. speed	60m/min
Transporting mass	150kg
Obstacle detection	Obstacle detection by laser range finder and track recognition
External dimensions	W500×H800×L700mm
Power source	24V battery unit
AGV function	Installation of MCAT

There are many possible applications. Since it can work as a conventional automatic guided-path following AGV, it could function very efficiently carrying material.

4. Specifications

Table 2 shows specifications of the service sector AGV. Our MCAT unit is adopted for its driving unit. Power supply is from a 24V battery unit. The maximum speed is 60m/min. For the guided path operation, the mode change between "service people tracking mode" and "normal AGV magnetic guided path mode" is possible.

5. Postscript

We have developed a service sector AGV for various service fields.

If service personnel wear a pre-set mark, the service sector AGV can follow the service personnel without requiring any major system reconstruction. Therefore, it can be programmed up and running immediately after the system induction. It is also equipped with the conventional AGV function of moving in a guided path. As a result, it can be used in various different fields.

In the future, we would like to improve the self-controlled moving performance by adding such functions as generating the environmental map and self-location presumptive function for wider applications.